Three Types of Pipeline Threats

**Static**
Manufacturing related defects
Welding/Fabrication related

**Time Dependent**
Corrosion related
Environmental cracking

**Random**
Third party damage
Incorrect operation
Outside force
Technologies for Pipeline Integrity

- Geometry pigs
- Low and high resolution MFL (magnetic flux leakage)
- Circumferential MFL (a.k.a. Transverse MFL)
- Ultrasonic inspection
- Ultrasonic crack detection
- Elastic wave vehicle
- EMAT (electromagnetic acoustic transducer)
Technologies for Pipeline Integrity

- Some mitigating technologies coming down the pipe
  - Improvements in in-line inspection technologies
  - Gas Coupled Ultrasonics
  - Remote Field Eddy Currents for unpiggable pipelines
  - Magnetic Telescope for unpiggable pipelines
  - NoPig
  - Mechanical damage pigs
  - Pipeline right of way management
    > Optical time domain reflectometry
    > Acoustic monitoring and impedance spectroscopy
  - Smart Pipe
RFEC Inspection Vehicle for Unpiggable Pipelines

- Bypass valve and bore restrictions
- Inspect multi diameter pipes
- Go through back to back bends
- Go around tight bends and miter bends
Remote Field Eddy Current (RFEC) Inspection of Unpiggable Pipelines

- Simple exciter coil, less than 1/3\textsuperscript{rd} of pipe diameter
- Sensor array adjusts to match pipe diameter while passing small openings
- Accuracy comparable to MFL
Unpiggable Pipelines
Ultrasonic Inspection
Gas Coupled Ultrasonics

- Direct measurement of wall thickness to a couple of percent
- Direct measurement of crack depths
- Already in use for non contact monitoring of burn victims

- Reduced sensitivity to material properties
- No liquids or wheels and not sensitive to stand off
High Pressure Chamber
Stepped Plate and Transducer
Results: Ultran #1 – SecondWave

Backwall Reflection Amplitudes as a Function of Pressure
Current Status

> Test new sensors from SecondWave
> Work with Tuboscope to run the technology in an operating pipeline as a wall thickness measuring device
> Continue sensor development with SecondWave and Weidlinger
> Develop better methods for corrosion measurement
> 2003 start looking at using GCUS for crack detection
Inspecting for Mechanical Damage

- Signals from standard MFL are inadequate

Combine Three Technologies

- Strong field – Weak field
- Circumferential MFL
- Non linear harmonics
Magnetic Flux Leakage Inspection
Magnetic Flux Leakage Inspection
Circumferential MFL

Defect 69
- 50% deep
- 6 inch long
- 1 inch wide

Defect 45
- 50% deep
- 1 inch long
- 6 inch wide
Non-Linear Harmonics

- Magnetic Flux Density, $B$
- Time, $t$
- Magnetic Field Strength, $H$

- Sinusoidal magnetic field strength, $H$
- Hysteresis nonlinearity

- NLH signal amplitudes
- Signal increase
- Axial stresses
- High stresses
Current Status

> Strong – Weak field magnetization has been developed for evaluation for commercialization

> Circumferential magnetization has been developed for evaluation for commercialization

> Non Linear Harmonics needs more development

> Criteria for assessment of mechanical damage have been set out
Smart Pipe

- Joint project with INEEL
- Measure stress and stress location
- Proved feasibility